Astrometry and Planetary Systems Theory

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Astrometry and Planetary Systems Theory

As noted in the Report of the ExoPlanet Task Force, there is a clear need to combine observational advances in detecting and characterizing exoplanets with theoretical work that supports these discoveries in several ways. We will focus here on theoretical work of most importance for astrometric planet discoveries, as opposed to, e.g., direct detection, where the theory of exoplanetary atmospheres becomes important.

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1. Orbital dynamics is essential for determining the best fit for the exoplanet orbits, determining orbital stability over long time periods,understanding orbital resonances and how they formed, and determining the interactions in multiple planet systems where some planetary orbits are poorly constrained or completely unknown.

Astrometry and Planetary Systems Theory

2. Theoretical work on planet formation mechanisms of the entire range of planets, from terrestrial planets, to ice giants, to gas giants, is necessary in order to place the exoplanet discoveries in the context of planetary system formation theories. Terrestrial planet formation is strongly influenced by gas giant planet formation and orbital evolution, so a complete theory of planet formation is needed in order to understand the formation of any one component. Theoretical models also provide testable predictions for what might be discovered, and therefore help to define the next steps in a long-term program of exoplanet discovery and exploration.

Habitable Planets per System

Chambers (2003)

[defined as terrestrial planets with masses greater that 1/3 that of Earth and Earth-like orbits]

Giant Planet System Configuration:	Giant Planet Formation Time: 0 Myr	3Myr	10Myr
• Normal Jupiter and Saturn	• 1.0	0.6	0.7
• Jupiter only, mass x 3	• 0.8	0.5	0.7
• Jupiter only, eccentricity = 0.4	• 0.1	0.2	0.4
• Jupiter & Saturn, both mass x 3	• 0.0	0.0	0.0
• Jupiter normal, Saturn mass x 3	• 0.3	0.6	0.4
• Jupiter & Saturn, both mass/3	• 0.8	0.9	0.9

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3. Understanding the extent of habitable zones around astrometric target stars will focus our attention on the best targets to search for the possible detection of habitable worlds. Recent theoretical work, e.g., has highlighted the potential of low mass, M dwarf stars as hosts for habitable worlds (Tarter et al. 2007). Because of their low mass and closeness, M dwarfs are attractive targets for exoplanet searches.

Astrometry and Planetary Systems Theory

Conclusions

Finding Earth-like planets has long been recognized as the outstanding goal of the field of exoplanet discoveries, and achieving this goal will require sustained support of theoretical modeling of planet formation, dynamics, and conditions for habitability.